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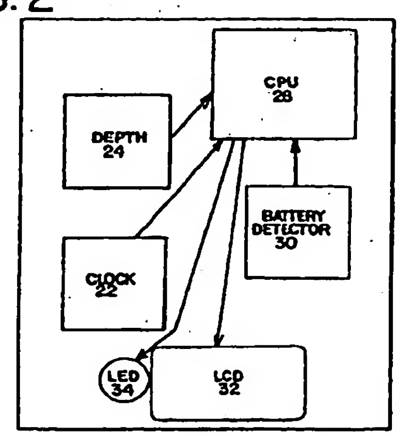
(54) Programmable dive computer

(57) An interactive dive apparatus (10) for use by a scuba diver to determine a maximum dive duration, including an input interface (12) for inputting dive specific parameters including a J-factor for adjusting a no-stop time calculation to compensate for various environmental and physiological parameters, a clock (22) for determining an elapsed dive time, and a depth sensor (24) for detecting a present depth and a maximum depth. The depth sensor (24) tracks diver dwell time in each of plural predetermined depth ranges, and a CPU (26) determines a no-stop time in accordance with the user inputted dive specific parameters and the detected dwell time. The interactive dive apparatus further includes a display screen (32) for displaying at least the no-stop time, elapsed dive time duration and the current depth.

FIG. 2



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[0014] During an emergency situation, the diver has a very limited ability to comprehend information. Moreover, the diver's response time is hampered if the information is unclear or needs to be found in several locations. Importantly, reduced visibility conditions may make it difficult or impossible for the diver to see a flashing LED light. Also, thick hoods such as used in dry suits impair the divers ability to adequately hear audible beeps clearly enough to ensure that a warning would be always noticed.

[0015] Consequently, there is a need for an improved method for alerting the diver to respond to an emergency situation.

[0016] The renting or sharing of diving equipment raises the need to clear the information stored in the diving computer. Previous approaches to resetting (clearing) stored data have included the use of mechanical switches that turn off the power to the unit making it "forget" the stored data. These mechanical switches such as HALL transducers or REED switches we prone to physical shock and corrosion.

[0017] Consequently, there is a need for an improved method for clearing stored data which does not rely on mechanical switches.

[0018] In response to these problems, one object of the present invention is to provide an improved dive computer which enables the user to tailor the no-stop time calculation to account for environmental and physiological parameters (J-factors).

[0019] Another object of the present invention is to provide an improved dive computer having user customizable display features allowing the user to display the type and amount of data displayed.

[0020] Another object of the present invention is to provide an improved dive computer whose display promptly alerts the user of an alert condition.

[0021] Yet another object of the present invention is to provide an improved method for clearing a dive computer of diver-specific parameters without the use of mechanical switches.

SUMMARY OF THE INVENTION

[0022] The above-identified objects we met or exceeded by an interactive apparatus for use by a scuba diver to determine a maximum no-decompression (no-stop) dive duration. The interactive apparatus (dive computer) includes an interface for adjusting the no-stop time calculation to account for environmental factors as well as aspects of the diver's physiology (J-factors). The dive computer further includes a hierarchical warning messaging system for warning the diver of various alert conditions. Moreover, the diver computer also provides an easy method for clearing the diver specific parameters from memory.

[0023] According to one aspect of the invention, the dive computer includes an input interface for inputting dive specific parameters including a J-factor for adjusting a no-stop time calculation to compensate for various environmental and physiological parameters, a clock for determining an elapsed dive time, and a depth sensor for detecting a present depth and a maximum depth, and tracking a dwell time in each of plural predetermined depth ranges.

[0024] A CPU communicating with the input interface, clock, and depth sensor determines a maximum no-decompression dive time (no-stop time) in accordance with the J-factor (described below) and the detected dwell time at each of plural predetermined depth ranges.

[0025] The interactive dive apparatus further includes a display screen for displaying at least the no-stop time, elapsed dive time duration and the current depth.

[0026] According to a further aspect of the invention, the interactive dive apparatus includes a hierarchical warning feature for alerting the scuba diver of an alert condition, such that if multiple alert conditions exist only a highest priority warning is displayed.

[0027] According to a further aspect of the invention, a background color of the display screen displays a first color designating a normal non-alert condition, a second color designating an intermediate alert condition, and flashes the second color to designate an advanced alert condition.

[0028] According to a further aspect of the invention, the CPU instructs the display screen to illuminate the second backlight color when the no-decompression dive time has expired, and instructs the display screen to display a decompression warning message in a warning field of the display.

[0029] According to another aspect of the invention, the interactive dive apparatus includes an ascent detection function for detecting a rate of ascent, and transmitting the detected rate of ascent to the CPU, wherein the CPU compares the detected rate of ascent with a predetermined maximum safe rate of ascent and instructs the display screen to display and flash the second backlight color when the detected rate of ascent exceeds the maximum safe rate of ascent. Moreover, the CPU instructs the display screen to display an ascent warning message in a warning field of the display. Notably, the ascent warning message has a higher priority than the decompression warning message.

[0030] According to another aspect of the invention, the interactive dive apparatus includes a battery monitor for alerting the CPU processor when a low battery condition exists, whereupon the CPU instructs the display screen to display the second backlight color and display a battery warning message in a warning field of the display screen. Notably,

Table I

	Environmental Related Factors
Water Temperature:	(Cold -) or (Warm +)
Diving Environment:	(Harsh -) or (Easy +)
	Diver Related Factors
Age:	(Old -) or (Young +)
Gender:	(Female -) or (Male +)
Health:	(Fair -) or (Good +)
Stamina:	(Tired -) or (Well rested +)
Fluid intake:	(Dehydrated -) or (Well hydrated +)
Protection:	(Wet suit -) or (Dry suit +)
	Diving Related Factors
Dives:	(Repetitive Dive -) or (Single Dive +)

[0038] The dive computer 10 includes an input interface 12 which, in the preferred embodiment consists of three wet contacts 12a, 12b, and 12c. The input interface 12 enables the diver to enter dive specific parameters by scrolling through a command tree.

[0039] Contact 12b is connected to a ground terminal, and terminals 12a and 12c are connected to a CPU 26 (FIG. 2) through 390k ohm series resistors (not shown), and are additionally connected to a positive side of a voltage source (not shown) via 1M ohm resistors (not shown).

[0040] One input is activated by touching contact 12a and contact 12b (ground terminal) at the same time, allowing a sub-micro ampere current to flow through the user's fingers. Another input is activated by touching contact 12c and contact 12b (ground terminal) at the same time, allowing a sub-micro ampere current to flow through the user's fingers. Moreover, touching all three contacts 12a-12c will activate both inputs (which also is the case when the device is submerged in water). Thus, by defining a distinct sequence of combinations, and setting a timeout to each stage of the sequence one can prevent inadvertent triggering. This aspect is important because, as will be discussed below, the memory contents may be deleted using a predetermined sequence of inputs, and it obviously would be undesirable to inadvertently clear the memory when the unit is in use.

[0041] In operation, the diver scrolls through the command tree by simultaneously depressing contacts 12a and 12b, and scrolls through entry values for a given command by simultaneously depressing contacts 12b and 12c.

[0042] Thus, for example, to enter a J-factor into the dive computer, the user scrolls through the various branches in the command tree until the J-factor command is selected and then the user scrolls through and selects an appropriate J-factor.

[0043] A functional description of the dive computer of the present invention will now be described with referenced to FIG. 2. The dive computer 10 includes a conventional ascent detector 20 for detecting a rate of ascent, a clock 22 for measuring an elapsed dive time duration and a conventional depth sensor 24 for detecting a present depth and storing a maximum dive depth.

[0044] The depth sensor 24 cooperates with the clock 22 to accumulate an amount of time the diver has spent in each of plural depth ranges. According to a preferred embodiment, the depth sensor determines a depth value once a second; however, other intervals are contemplated.

[0045] The dive computer 10 includes a CPU 26 which uses the depth sensor values from the depth sensor 24 as an input for determining the Buhlmann algorithm. According to a preferred embodiment, the CPU 26 determines an average depth every six seconds, and uses the determined average depth in the Buhlmann algorithm however, other intervals are contemplated.

[0046] A display screen 32 is provided for displaying dive related information. According to the preferred embodiment, the display screen 32 is a conventional LCD screen. One of ordinary skill in the art will readily appreciate other display screens which may readily be substituted for an LCD screen.

[0047] According to one aspect of the present invention, the dive computer 10 incorporates a hierarchy of warning messages for alerting the scuba diver of an alert condition. The relative ranking of the warning messages determines which message will be displayed in the event that two or more alert conditions occur simultaneously.

invention enables diver specified information to be cleared from memory quickly and easily. Importantly, the software switch does not rely on a mechanical switch such as utilized by conventional dive apparatus.

[0060] It should be appreciated that the use of a software switch according to the present invention avoids the corrosion and impact related problems associated with mechanical switches and the like.

[0061] In operation, the software switch is selected by entering unique sequence of commands into the input interface 12. Importantly, as described above, the input interface 12 incorporates a lock-out mechanism which prevents entry of commands via the input interface 12 when the contacts 12a, 12b and 12c are wet. Thus, the accidental actuation of the software switch during a dive is assured.

[0062] While various embodiments of the present interactive dive computer have been shown and described, it should be understood that other modifications, substitutions and alternatives are apparent to one of ordinary skill in the art. Such modifications, substitutions and alternatives can be made without departing from the spirit and scope of the invention, which should be determined from the appended claims.

[0063] Various features of the invention are set forth in the appended claims.

Claims

1. An interactive apparatus for use by a scuba diver to determine a maximum dive duration, said apparatus characterized by:

   input means (12) for setting dive specific parameters including a J-factor parameter for adjusting a no-stop time calculation to compensate for various environmental and physiological parameters;
   clock means (22) for determining an elapsed dive time duration;
   depth sensor means (24) for detecting a present depth and a maximum depth, said depth sensor means tracking a dwell time in each of plural predetermined depth ranges;
   processor means (26) communicating with said input means (12), said clock means (22) and said depth sensor means (24), said processor means determining a remaining no-stop time in accordance with said J-factor and said detected dwell time, and
   display means (32) for displaying at least one of said maximum depth, said current depth, said elapsed dive time duration and said remaining no-decompression dive time.

2. An interactive apparatus according to claim 1, further characterized by:

   hierarchical warning means (34) for alerting the scuba diver of an alert condition, whereby if multiple alert conditions exist only a highest priority warning is displayed.

3. An interactive apparatus according to claim 2, further characterized by:

   said display means displaying a first color (34G) to designate a normal non-alert condition,
   said display means displaying a second color (34R) to designate an intermediate alert condition, and
   said display means displaying flashes said second color to designate an advanced alert condition.

4. An interactive apparatus according to claim 3, further characterized by said processor means (26) instructing said display means (32) to display said second color (34R) when said no-decompression dive time has expired, and instructs said display means to display a decompression warning message (DECOxx) in a warning field of said display.

5. An interactive apparatus according to claim 4, wherein:

   said processor means (26) includes an ascent detection function which determines a rate of ascent by monitoring said detected depth values over a predetermine time interval, said processor means comparing said rate of ascent with a predetermined maximum safe rate of ascent and instructs said display means (32) to display and flash said second color (34R) when said rate of ascent exceeds said maximum safe rate of ascent, and instructs said display means to display an ascent warning message (SLOW) in a warning field of said display, said ascent warning message having a higher priority than said decompression warning message.

6. An interactive apparatus according to claim 5, further comprising:

   battery monitoring means (batt) for alerting said processor when a low battery condition exists;

FIG. 1

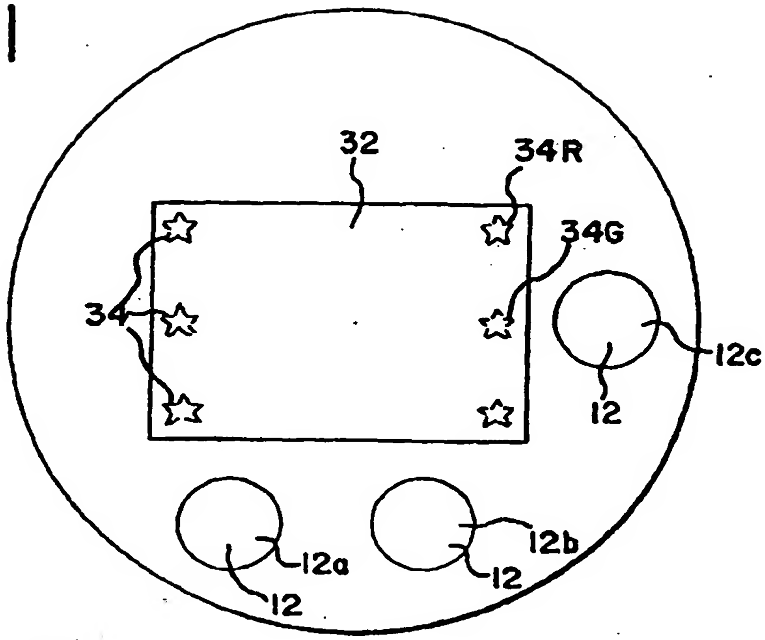
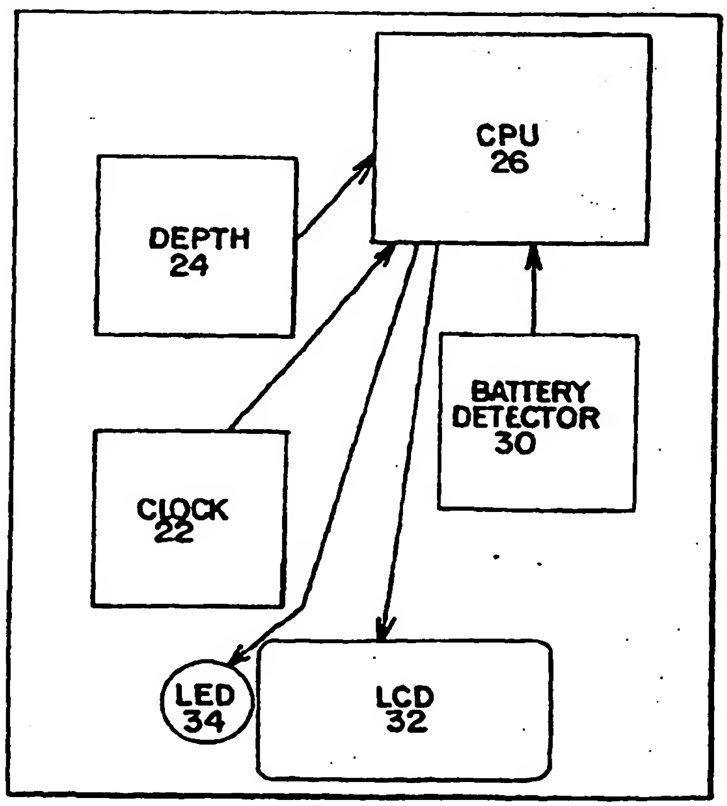

32
34R
34G
34
12c
12
12a
12
12b
12

FIG. 2


CPU
26
DEPTH
24
BATTERY
DETECTOR
30
CLOCK
22
LED
34
LCD
32

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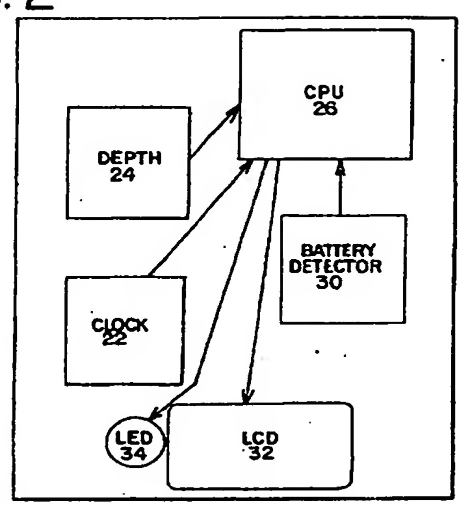

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 40 0059

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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